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ADVANCE REPORT

on the

SEDIMENTATION SURVEY OF BLACK CANYON RESERVOIR

EMMETT, IDAHO

May 21 to August 13, 1936

by

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Sedimentation Studies
Division of Research
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GENERAL INFORMATION

Location (Fig. 1):

State: Idaho.

County: Gem, Secs. 22, 23, 24, 25, 26, T. 7 N., R. 1 W. and Secs. 19, 20, 21, 28, 29, 30, T. 7 N., R. 1 E.

Distance and direction from nearest city: 5 miles northeast of Emmett, Idaho.

Drainage and backwater: The dam is on the Payette River. Water is also impounded on Squaw Creek, a tributary.

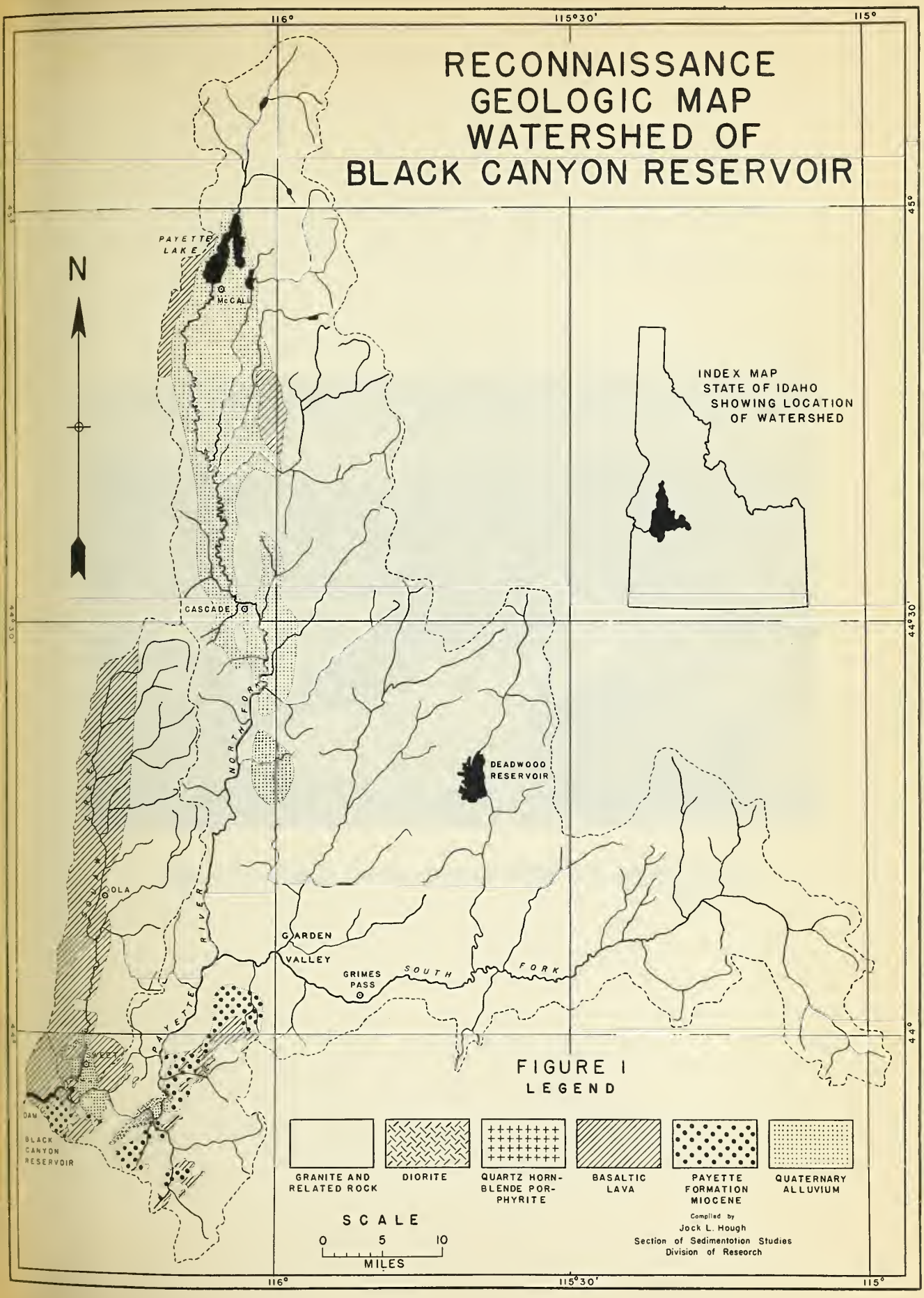
Ownership: United States Government. The project is operated by the Bureau of Reclamation, Department of the Interior.

Purpose served: Used primarily for irrigation. The power output is leased to the Idaho Power Company from October 15 to April 14 each year.

Description of dam: The dam is a gravity-type concrete structure, consisting of a slightly arched overflow section across the river channel and straight abutment sections on the sides (fig. 2). The over-all length of the dam is 1,134 feet, and the height is 94 feet above the stream bed and 184 feet above the foundation. It was necessary to excavate in the deepest part of the river channel to a depth of 90 feet below low water to secure a suitable foundation. The crest width is 16 feet and the maximum width at the base is 130 feet. The upstream faces of the abutment sections are vertical.

The overflow-type spillway comprises three straight sections constructed at small angles with the abutment sections and with each other so as to provide a slight arch effect. Overflow is controlled by three steel drum gates each 64 feet long by 14½ feet high. The spillway

RECONNAISSANCE GEOLOGIC MAP WATERSHED OF BLACK CANYON RESERVOIR



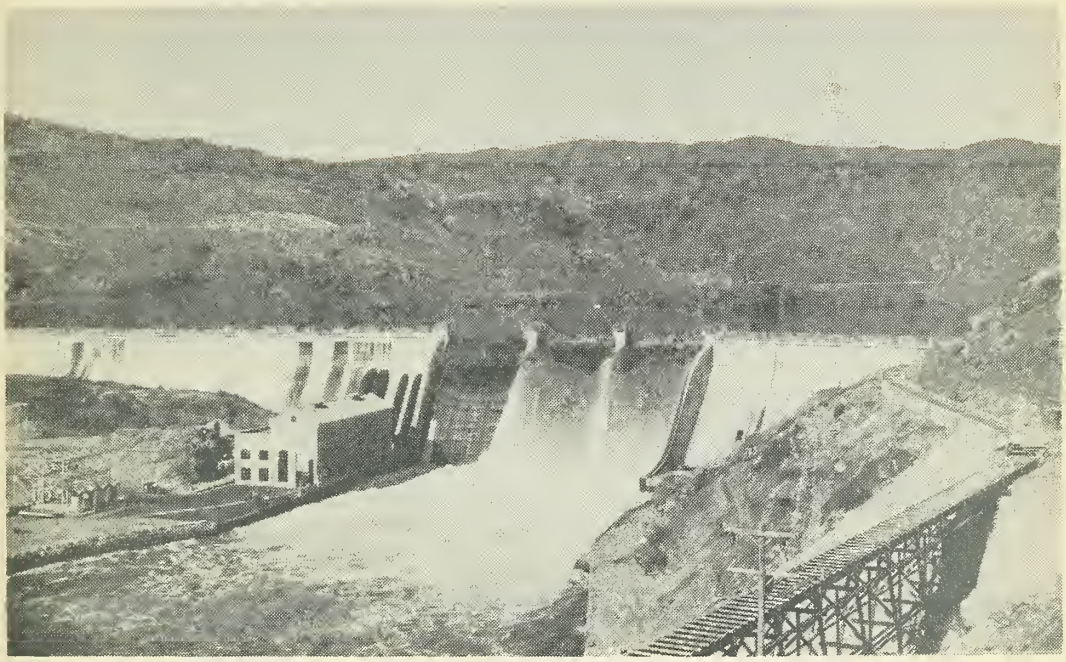


Figure 2.--Black Canyon Dam spillway and power house.

has a total crest length of 192 feet and a total discharge capacity of 40,000 cubic feet per second. The spillway crest, at the top of the gates, is 90.5 feet above the stream bed and 2,497 feet above mean sea level, as determined by the United States Bureau of Reclamation.

The Emmett Irrigation District Canal on the north side of the river is supplied with water from the reservoir by pumping against a 25-foot head. The pumping equipment consists of two vertical units with a combined capacity of 300 cubic feet per second, each unit consisting of a hydraulic turbine and seven pumps keyed to a common shaft. Water from the pumping units passes through a 7-foot penstock into a conduit within the dam that extends to the north abutment.

The canal on the south side of the river receives water from the reservoir by gravity flow, controlled by outlet gates.

The Black Canyon Canal of the Payette Division, Boise Irrigation Project, now under construction (1937) by the Bureau of Reclamation, is also located on the south side of the river and will, when completed, receive water by gravity flow as does the present canal on this side of the river. Two radial gates, 14 feet long by $10\frac{1}{2}$ feet high, will provide for the additional diversion of water.

Two sluiceways 5 feet in diameter, controlled by gates, are located at the base of the dam in the spillway section. Adjacent to the spillway in the north abutment section are two 5-foot pumping unit penstocks and two 7-foot power-unit penstocks with intakes about 25 feet below spillway level.

Date of completion of dam: June 1924.

Average date of survey: June 1936. Total age of reservoir to date of survey: 12 years.

Length of lake (original and present): 8.8 miles; Squaw Creek arm 1.7 miles.

Area of lake at crest stage:

	Acres
Original	1,069
Present	1,055
Reduction	14

Storage capacity at crest level (determined by this survey):

	Acre-feet
Original	38,152
Present	34,011
Loss due to silting	4,141

General character of reservoir basin: The reservoir lies largely within Black Canyon, which is a comparatively narrow section of the Payette River Valley resulting from incision of the stream across beds of lava that dip about 20° westward. The zigzag trend of the reservoir is the result of the influence of rock structure on the river course. The main body of the lake maintains a fairly constant width, commonly ranging from 900 to 1,200 feet, for a distance of 4 miles from the dam. Above this section the lake narrows, and at the junction of the Payette River and Squaw Creek arms, about 5 miles from the dam, its width is 450 feet.

Above the mouth of Squaw Creek, the Payette River arm has an average width of 560 feet for about one-half mile, and then widens over a flooded meander plain to an area measuring 2,400 by 3,400 feet, in which the depth of water averages about 15 feet. Upstream from this flooded meander plain the lake is shallower and is restricted essentially to the channel of the river, which ranges in width from 340 to 1,100 feet.

The Squaw Creek arm is over 500 feet wide at its mouth but narrows to about 300 feet at a point 1,200 feet upstream and maintains this width for three-quarters of a mile, above which it narrows to about 60 feet in the immediate channel for the upper 4,000 feet of backwater.

The valley sides surrounding the reservoir basin range from very steep slopes on bare rock to moderate

or gentle slopes on mantle rock or old alluvial material (fig. 2). Below reservoir crest level the valley sides slope down to a poorly developed flood plain in which the river channel is incised. The maximum original depth of the lake near the dam was 93 feet, and at the confluence of the two branches it was 42 feet.

Area of watershed: 2,540 square miles, not including the 210 square miles of drainage area above Payette Lakes.

General character of watershed: (See fig. 1): The watershed of Black Canyon Reservoir may be conveniently divided into two parts. The larger part is that drained by Payette River, embracing about 2,200 square miles and lying on the Idaho Batholith in the Northern Rocky Mountain physiographic province. Squaw Creek, the only large tributary of the reservoir, has a watershed of about 350 square miles lying partly on the southwestern edge of the batholith and partly on the Tertiary lavas to the west. The areas drained by the two streams are distinct in many ways.

Payette River watershed.

Geology. The bedrock of the Payette River watershed consists almost entirely of granite and related rock types. The granite, which forms the bulk of the Idaho Batholith, is a coarse-grained biotite-bearing variety and is cut by numerous acidic and basic dikes. The whole mass is jointed and faulted. A tongue of the Miocene Payette Formation, a lacustrine series of poorly consolidated sands and gravels with some associated lava flows, lies to the east and south of the river, between the junction of the north and south forks of the Payette River and the divide south of Horseshoe Bend. A small area of lava lies in the Payette watershed immediately above the reservoir, and there are 26.7 square miles of lava in two patches in the vicinity of Payette Lakes, near the head of the north fork of Payette River.

Terraces of old river gravel and sand, probably of early Pleistocene age, occur in the valley of Payette River in several areas of relatively small extent. Quaternary alluvium covers the floor of Long Valley, which extends along the north fork of Payette River from a point several miles south of Cascade to Payette Lakes.

Pleistocene glaciation, which extended to levels as low as 5,000 feet in the mountains of the watershed, left deposits of glacial drift that are locally of some importance.

Topography and drainage. The greater part of the Payette section of the watershed is mountainous in character, attaining elevations as great as 10,700 feet. Approximately 65 percent of the watershed is more than 5,000 feet above mean sea level, or 2,500 feet above Black Canyon Reservoir. The drainage system is well developed, and the major streams have narrow valleys incised well below the general upland level.

The natural drainage from this watershed is interrupted by the Payette Lakes on the north fork and by Grimes Pass and Deadwood Reservoirs on the south fork. In order properly to express reservoir sedimentation in terms of silt output per unit of drainage area, it was necessary in this case to determine whether or not the drainage areas of the upstream lakes and reservoirs should be included as parts of the contributing watershed.

The Payette Lakes were found by examination to be natural settling basins that remove practically all the sediment from the water passing through them. For this reason the 210 square miles of drainage area above these lakes was not considered as part of the contributing watershed of Black Canyon Reservoir.

The dam at Grimes Pass, about 4 miles above Garden Valley on the south fork, is about 200 feet long and 50 feet high, including 4-foot flashboards. Water is backed up about half a mile in the channel. The purpose of the reservoir is power development, the average output being about 900 hp. According to local information the original dam was built in 1909, but has since been washed out and replaced. When the dam was visited by the writers, sand was visible within a few feet of crest level, except near the turbine intake where a suction pump is used to remove sediment and discharge it below the dam. The reservoir is so nearly full of sediment that it is obvious that practically the entire load of the river has been carried over the dam for several years.

Deadwood Reservoir lies at an elevation of more than 5,000 feet on Deadwood River, a northern tributary of the south fork of the Payette River, about 90 miles upstream

from Black Canyon Reservoir (fig. 1). The dam, completed in April 1931, is 700 feet long, 160 feet high at the spillway, and impounds 164,000 acre-feet of water. This storage is utilized to provide a regulated flow for the power plant and irrigation canals at Black Canyon. Water is released through two 66-inch conduits at the base of the dam. The usual draw-down by the end of the summer is about 120 feet.

Investigation of the reservoir bottom with the silt-sampling spud revealed an absence of fine sediment. Coarse sand, interpreted as original mantle rock was found at several points as much as 96 feet below crest. This condition would be expected from the character of the watershed, which is well forested and receives a large part of its precipitation in the form of snow. Inasmuch as this reservoir has been in operation for only half the life of Black Canyon Reservoir, and during that time has apparently accumulated little or no sediment, its drainage area of 110 square miles is in effect a part of the contributing watershed of Black Canyon Reservoir notwithstanding a virtual absence of sediment output.

Soils. The granite of the region disintegrates to form a coarse-grained, gray or yellowish-gray soil which is shallow over most of the area. At lower elevations, particularly in the valley bottoms, mass movement from adjacent slopes has built up a considerable thickness of partially weathered debris. Soil profiles are generally poorly developed in the region.

Land use: Forests cover a very large percentage of the Payette watershed. The Payette National Forest, lying largely in the Payette River watershed, was established in 1905. In 1907 its area was approximately 1,250 square miles, and in 1920, 960 square miles were added. There has been extensive timber cutting for the past 20 years in the vicinity of Long Valley. Considerable areas in Garden Valley, on the south fork, were cut over 40 to 50 years ago.

Fire losses have been very severe in some portions of the forest, particularly at the lower elevations along the south and middle forks of the Payette River. The largest single burn was the Quartzburg fire of 1931, which covered about 20,000 acres along the south fork in the vicinity of Garden Valley. The Boiling Springs fire of 1934 covered 10,000 acres, mostly north of Boiling Springs

on the middle fork. At least a dozen other fires covering one to three thousand acres have occurred at various places in the forest.

Grazing is carried on extensively along the north fork of Payette River on the steeper lands encircling Long Valley above Cascade. Within the Payette National Forest approximately 80,000 sheep and 6,000 cattle are grazed each year.

Farming is practiced on a small part of the watershed. The largest area of farm lands is on the flats of Long Valley, and a second area of some importance is in Garden Valley. In addition there are a few scattered farms, principally on the terrace lands along the main streams.

Placer mining operations, confined principally to terrace gravels along the south fork, have caused an unknown quantity of debris to be washed into the river. At present very little placer work is in progress.

Erosion conditions. There is no serious problem of erosion (by surface wash) in the Payette National Forest, according to W. B. Rice, supervisor of Payette National Forest.[2] Examination by the writers of parts of the Payette River watershed lying outside the Forest indicates that the same is true of practically the entire drainage basin. A large amount of debris reaches the streams of the region, however, because the drainage basin is one of youthful topography with very steep slopes, on which soil creep is normally an active process. In certain limited areas, notably in the vicinity of Long Valley, overgrazing and trampling by stock have caused moderate acceleration of soil loss, principally through sheet erosion.

Squaw Creek watershed.

Geology: This area consists of a northward-trending valley about 40 miles long, which may be divided longitudinally into two parts on the basis of its rock types. The eastern part, including nearly 60 percent of the valley, is underlain by granite, and the western part, comprising about 40 percent of the valley, by basaltic

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[2]Personal communication to J. L. Hough, Aug. 3, 1936

lava. The lava area crosses to the eastern side of the valley at its extreme southern end, and a few square miles of alluvium occur in the valley at the south end of the watershed.

Topography and drainage. Elevations range from about 7,000 feet at the headwaters of Squaw Creek to 2,497 feet at spillway level. The topography is, in general, rough and semimountainous (fig. 3). The divide on the west side of Squaw Creek Valley culminates in a bold, even-crested ridge named Squaw Butte, whose crest has an elevation of approximately 5,000 feet at its southern end and 4,500 feet at its northern end.

The drainage system is well developed, and all the larger tributaries have bedrock bottoms, except in the major valleys where they flow over sandy or gravelly alluvial deposits.

At high altitudes on the east side of the Squaw Creek watershed several small meadows occupy basins along minor drainage-ways. No effort was made to determine the origin of these high basins, but they were found to contain alluvial deposits.

Soils. Soils of the Squaw Creek watershed have been classified on the basis of their geological origin by the staff of the Squaw Creek project of the Soil Conservation Service. The approximate percentage of the watershed occupied by each class, is given in the following tabulation.

Table 1.--Soil types in the Squaw Creek watershed

Group	Description	Area
		Percent
1....	Residual soils from granitic rock	65
2....	Residual soils from basaltic rock	30
3....	Recent alluvial soils)	
	)	5
4....	Old alluvial soils)	
Total	.....	100

Figure 3.--Squaw Creek Valley, north of Ola.

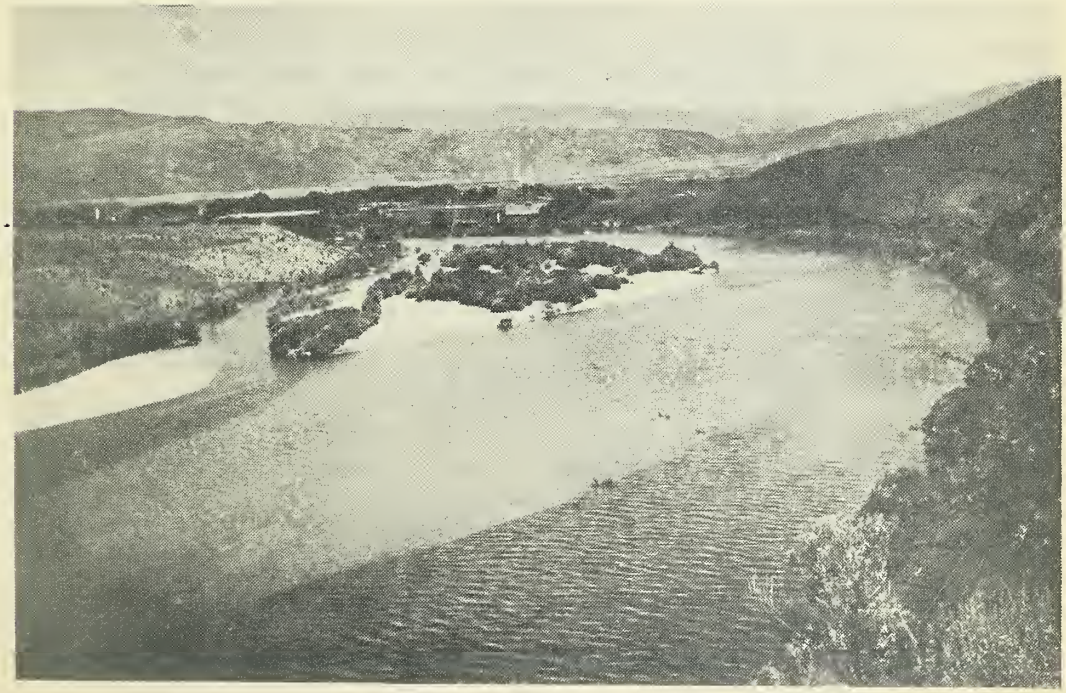
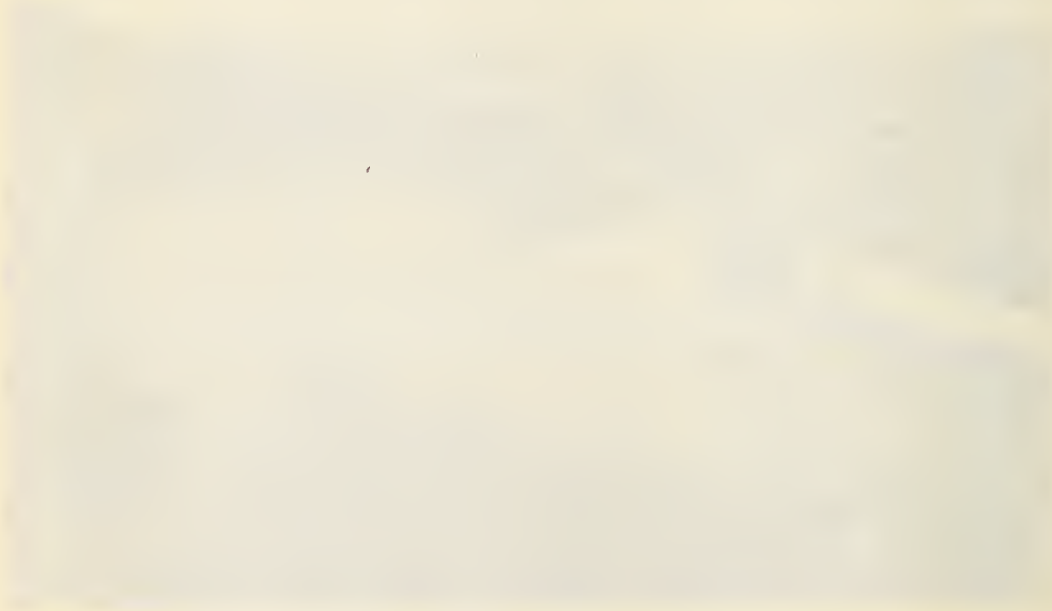


Figure 4.--Sand and gravel bars in the Payette arm of Black Canyon Reservoir. (Note the submerged bar in the center and left foreground.)



The fourth type, old alluvial soils, of table 1, includes the fifth type of the Squaw Creek project classification, which is lacustrine soils. This type was classified in the belief that a large mass of gravel and sand lying in lower Squaw Creek Valley was an outlier of the Miocene Payette Formation. This material is now well exposed in several new road cuts and shows strong evidence of a younger, fluviatile origin, probably contemporaneous with the old river deposits on which the fourth soil type has developed.

Residual soils from basalt are generally shallower than those from granite, and the latter are rarely more than 3 feet deep. Both types of residual soils are moderately high in organic matter.

Land Use. The history of Squaw Creek watershed is typically the history of western intermountain cattle and sheep country. The valley development began about 1862. Within a few years all the land suitable for grazing was in use, primarily as cattle range. About 1890 commercial sheep men appeared on the western edge of the watershed and began pushing their flocks down into the cattle country. Between 1910 and 1915 the present grazing boundaries were fairly well determined. During the spring and fall the sheep were generally restricted to trailing range on Squaw Butte and the slopes to the north, whereas during the summer they were trailed into the high mountains back of Cascade, Idaho, for grazing. Fences were built in the lower cattle range between 1880 and 1900. Range conditions were much better in the early days of occupation than at present. Noticeable decline began about 1900. The greatest decline has occurred during the past 10 years. Although augmented to some extent by subnormal rainfalls, overgrazing and erosion are believed to be primary causes of range deterioration.

Cultivation of the land was not carried on to any appreciable extent until the Brownlee and other farming districts were opened up shortly after 1900. During the World War, when wheat prices were high, a considerable part of the previously plowed land, as well as some virgin range land, was planted in wheat. Since then, topsoil losses have increased greatly and have amounted to 100 percent on some of the steeper fields as shown by reconnaissance erosion surveys. Wheat is still grown in many of the fields, although, as a result of topsoil losses and poor farming practices, the yield is now very low.

The following table gives a summary of the land use in Squaw Creek watershed in 1935.

Table 2.--Land use in the Squaw Creek watershed

Use	Acres	Percent
Grazing	105,000	46.67
Forest	100,000	44.44
Cultivated	20,000	8.89
Dry farming... 16,000 acres		
Irrigated..... 4,000 acres		
	225,000	100.00

The bulk of the irrigated land lies along Squaw Creek in the vicinities of Sweet and Ola. Dry-farming lands are scattered on the higher ground.

Erosion conditions. The farm lands are eroded to various degrees, depending upon the topography, type of soil, and use and management of the land. Small gullies occur on the gently sloping irrigated bottomlands, owing, in large part, to lack of control of waste irrigation waters and, to some extent, to heavy run-off from adjoining slopes. Dry-farming areas on the steeper uplands have suffered more serious erosion. Shoestring gullies appear on many of the steeper slopes, especially those in winter wheat, and large gullies have cut numerous fields into small patches. From such fields 50 to 75 percent and in some places as much as 100 percent of the topsoil has been removed.

Forest grazing lands in the Squaw Creek watershed in general show only slight to moderate accelerated erosion. Some areas, however, are seriously trampled and overgrazed and are undergoing severe erosion. Sagebrush and grassland grazing areas have poorly developed soils and scanty vegetation, a condition that is apparently normal under the low rainfall of the area. Slight to moderate sheet erosion has affected the greater part of this area, and small gullies occur locally.

The Soil Conservation Service began conservation work in the Squaw Creek watershed about January 1, 1936. Retirement of steeply sloping fields to forage crops, restriction of grazing, and protection of irrigation channels and natural stream banks are the major features of the program.

Mean annual rainfall: 20 to 26 inches at stations in the Payette River watershed, over a period of 27 years (United States Weather Bureau); 21.33 inches at Ola, in the Squaw Creek watershed, over a period of 27 years (private record); 10.95 inches at Emmett, 5 miles below Black Canyon Reservoir, over a period of 30 years (United States Weather Bureau).

Inflow into reservoir: 2,207,000 acre-feet per year average from the Payette River, as calculated from measurements by the United States Geological Survey, made 10 miles upstream, over a period of 24 years. The inflow from Squaw Creek was estimated as 28,000 acre-feet per year, by comparison of watershed areas and average annual precipitation in the two watersheds. The total average inflow, including these two figures, is, therefore, about 2,235,000 acre-feet.

Power development. The installed power equipment consists of 2 units, each rated at 5,000 kv-a, and generating a total of 6,705 hp. The operating head under full reservoir is 88 feet. The draft under full plant operation with full reservoir is 1,250 cubic feet per second.

Irrigation. The annual amount of water used during the growing season is 500,000 acre-feet. Approximately 80,000 acres are irrigated and receive an average depth of 6 feet of water each year.

HISTORY OF SURVEY

The survey of Black Canyon Reservoir was made during the period May 21 to August 13, 1936 by the western reservoir party, Section of Sedimentation Studies, Division of Research. The personnel of the party consisted of Elliott M. Flaxman, chief, Jack L. Hough, assistant chief, Leland H. Barnes, Glen Petrick, and Alvin T. Talley.

The establishment of a triangulation system of 48 stations constituted the initial field work. From this control the crest contour of the reservoir, 28 miles in length, was mapped

on a scale of 1 inch to 200 feet. Original and present capacities and silt volumes were determined by the range method of survey.[3] Soundings and silt measurements were taken on 68 ranges. To provide a basis for future re-surveys the range ends were marked with pipe stamped with the station numbers and set in concrete.

The light blanket of fine-grained sediments in the lower basin was easily penetrated by the silt-sampling spud, but the thicker deposits of coarser sediments above range R55-R56, extending to the head of deposition in both Squaw Creek and Payette River arms, required the use of a soil auger. On range R111-R110 (fig. 4) it was not possible to determine the original elevation of the gravel bar by auger borings, but information of local inhabitants, believed to be reliable, indicates that the original bar was 1 to 3 feet below crest. The original profile across this bar was therefore drawn to conform with this evidence.

In addition to the ranges used in measuring water and silt depths, a series of 8 special ranges was established to provide a basis for determining the volume of material shifted below crest elevation by wave action with consequent displacement of storage capacity. Detailed profiles, extending far enough each way from the crest line to include the limits of possible change by wave erosion over a considerable period of time, were prepared from closely spaced levels and soundings. The upper ends of the ranges were marked with pipe set in concrete and the orientation of each with respect to another range end or other permanently marked point was recorded. This will make it possible at some future time to plot new profiles on each range and compute the volume of material shifted below crest elevation in the intervening period.

The Soil Conservation Service through the Squaw Creek Demonstration Project has constructed a series of 3 rock wing dams to protect badly eroding channel banks on Squaw Creek about one-half mile north of the village of Sweet. These were completed before the spring flood season of 1936. By summer of the same year the stream had already deposited a considerable amount of sediment in the lee of the wing dams. In the present survey five ranges were established

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[3]Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524, 129-135, 1936.

across this section of the channel in order to make possible, by comparison with neighboring unprotected banks, a future evaluation of the effectiveness of this method of protecting vulnerable banks from current action, and to show the approximate quantity of potential reservoir sediment that is being deposited behind the wing dams.

Operations of the Squaw Creek project also included a diversion of the stream channel to eliminate a meander about 2 miles north of Sweet. The purpose was twofold: (1) to prevent further destruction of lands adjacent to the channel and (2) to provide additional arable acreage in a single unit for the owner of the property thus permitting necessary land use readjustment on the farm. Small dams were built across the old channel to retard flood currents and invite deposition of sediment. The new channel was located by digging a ditch of small cross-sectional area to a depth that would allow the lowest flow of the creek to pass. The new channel has widened considerably during the succeeding year. As a supplement to the present survey, a series of 11 ranges was established across this section of channel including the meander cut-off, to furnish a check on the rates of enlargement of the new channel and of filling of the abandoned channel under these special conditions. The end points of these ranges were marked with iron pipe.

ACKNOWLEDGMENTS

The Soil Conservation Service wishes to thank E. B. Debler, hydraulic engineer of the Bureau of Reclamation, Denver, Col., and G. R. Larson, superintendent of Black Canyon Dam, at Emmett, Idaho, for information on the dam and reservoir.

The Forest Service, through W. B. Rice, supervisor of the Payette National Forest, supplied information on that portion of the Payette River watershed lying within the Payette National Forest. J. P. Thompson, project manager of the Squaw Creek project, Soil Conservation Service, Emmett, Idaho, furnished assistance and information on special survey problems and on watershed studies.

SEDIMENT DEPOSITS

Character of sediments

The sediment of the bottom-set beds in the lower part of

the reservoir varies from a nearly black, very fine silt near the dam to a medium, dark brown silt on range R55-R56 just below the mouth of Squaw Creek. The Squaw Creek delta (fig. 5) is made up of coarse brown silt with interbedded layers of medium to coarse sand that increases in abundance toward the head of the delta. The silt is similar to that exposed in flood-plain deposits of the Squaw Creek Valley above the reservoir. In the Payette River arm of the reservoir, sandy silt, grading upstream into fine sand, extends from range R58-R59 at the mouth of Squaw Creek to the middle of the wide, flooded meander plain in segments 54 to 57. Farther upstream the sediment is dominantly a medium to coarse, clean sand. Pebbles and cobbles increase in abundance and become prominent towards the head of backwater. This reservoir has an unusually well-defined gradation in texture of sediment from the head of backwater to the dam, indicating a progressive settlement of rather uniform rate as the stream flow passes through the lake.

Distribution of sediment

The variation in the thickness of sediment in Black Canyon Reservoir is presented graphically in figure 7, which shows the original and present average water depths on successive ranges from the dam to the heads of backwater.

The section of the reservoir bounded by the dam and range R42-R43 contains only a thin layer of sediment. The deposit is generally confined to the flooded stream channel and flood plain, little or no silt adhering to the valley slopes. The average thickness of sediment in this section is 0.9 foot. In contrast the section bounded by ranges R44-R45 and R55-R56, just below the mouth of Squaw Creek, the chief silt carrier, shows an increase in average thickness to 3.0 feet.

The most abrupt change in silt thickness occurs in segment 36, bounded by ranges R55-R56 and R57-R58. The thickness increases from an average of 4.5 feet and a maximum of 6.5 feet on range R55-R56 to an average of 9.0 feet and a maximum of 23.2 feet on range R57-R58. The 23-foot silt depth is the maximum for the reservoir.

Between range R55-R56 and the head of deposition in the two arms (a distance of 1.99 miles in Squaw Creek and 4.13 miles in Payette River) the volume of sediment is 5 times as great as in the section extending from the dam to range R55-R56 and including 5 miles of the reservoir. As a result, that portion of the reservoir above range R55-R56 has lost 40 percent of its original capacity of 3,149 acre-feet, whereas the

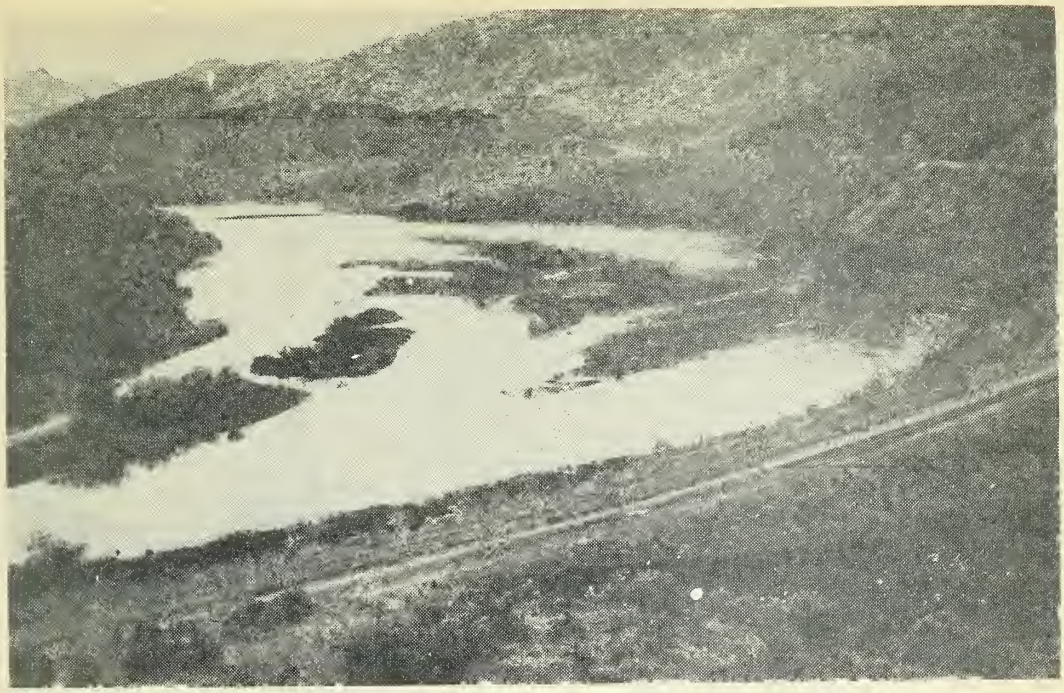

Figure 5.--Delta deposit in the Squaw Creek arm of Black Canyon Reservoir. (Looking downstream from head of delta.)

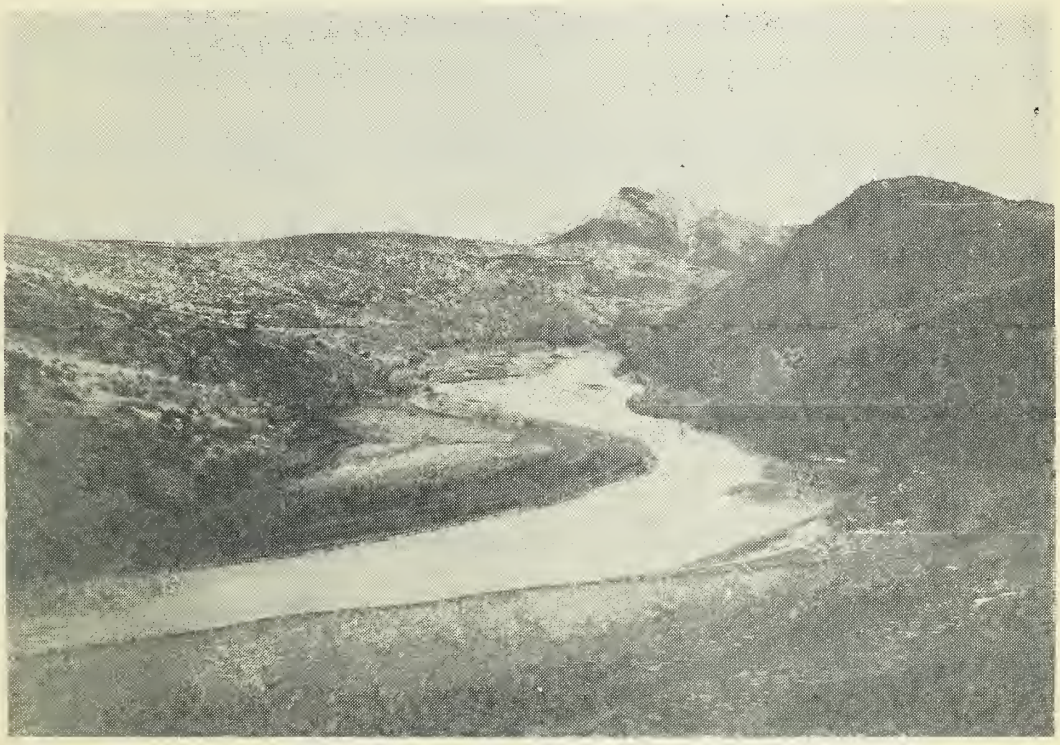

Figure 6.--Silt deposits of Squaw Creek delta exposed by 14.5-foot draw-down. Downstream from view of Figure 5.

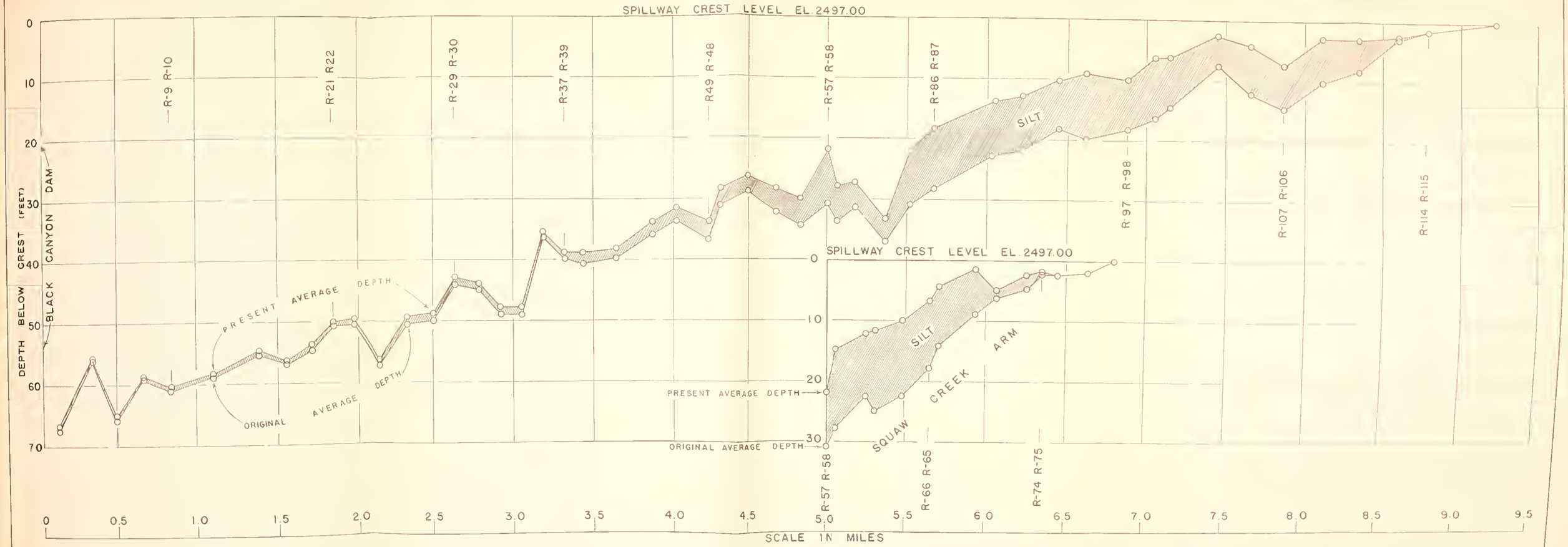

Figure 7 - LONGITUDINAL PROFILE SHOWING SILT THICKNESSES, BLACK CANYON RESERVOIR, EMMETT, IDAHO

remainder of the reservoir has lost less than 3 percent of its original capacity of 29,510 acre-feet.

In the Payette River arm above the flooded meander plain, and also in the Squaw Creek arm, the occurrence of coarse sediment mainly on the inside of bends becomes increasingly more pronounced upstream, clearly reflecting a gradual decrease downstream in the strength of inflowing currents. The gradient of the water surface in the Payette River arm, measured during flood discharges in 1936, indicates the magnitude of such currents. At instrument station 525 the elevation of water surface was about 3 feet above reservoir crest and in the flooded meander plain, 2.1 miles downstream, it was 0.2 foot below crest (or at the same elevation as at the dam).

The lower margins of the deltas in the Squaw Creek and Payette River arms may, with reasonable accuracy, be placed at ranges R55-R56 and R82-R83, respectively. The line of separation between bottom-set and delta fore-set beds is not as easily distinguished through change in texture as by the abrupt change in slope and thickness. The margin of the Squaw Creek delta from range R57-R59 to range R55-R56 consists both of Payette River and Squaw Creek sediments, and the total of 528 acre-feet for the quantity of sediment in this delta to the upper limit of backwater on this arm includes a minor amount received from the main river. Range R82-R83, the boundary of the Payette River delta, was drawn on the same basis as that of Squaw Creek with the exception that textural distinctions were clearer here. The amount of sediment computed to be within the Payette River delta is 2,657 acre-feet.

Water withdrawals during the fall and winter months have lowered the water surface as much as 14.5 feet below crest (fig. 6). This probably causes an annual redeposition of part of the Squaw Creek and Payette River channel deposits at lower elevations in the reservoir.

Origin of sediment

The sediments carried by the Payette River result chiefly from erosion of disintegrated rock and soils derived from the granite of the Idaho Batholith. Basalt outcrops in only 2 percent of the Payette watershed, and the residues obtained from that area are not of sufficient amount to warrant consideration in this report.

The granite weathers readily into coarse sands which are

apparently the major load of the Payette River. A mechanical analysis of soils derived from granite of the Idaho Batholith in the adjacent Boise River watershed shows an average clay content of 9 percent, an average silt content of 10 percent and the remainder sand, 31 percent of which consists of particles in excess of 2 mm in diameter.[4]

The soils and sand consisting of freshly decomposed granite are made available to the streams partly by soil creep and slump resulting from the general steepness of slope in the watershed. Soil creep apparently counterbalances the tendency of sheet wash to remove only the finer constituents of the soil. These characteristics of the source material and watershed may indicate why the Payette River, even in flood stage, is a clear stream.

Squaw Creek, on the other hand, appears turbid during heavy discharge, and the nature of the deposits in the Squaw Creek arm indicates that relatively fine sediment makes up the greater proportion of the load of this stream. It is believed that the greater part of the load of Squaw Creek is derived from the southern half of its watershed, because an examination of the stream during the waning of its flood showed that the water was more turbid in the southern part of its course than at a point about half way up Squaw Creek Valley. The farm lands that have suffered the greatest losses by erosion are in the southeastern part of the valley. A considerable, though probably minor, part of the sediment of the creek is acquired by bank cutting in the relatively flat portion of the valley within 4 miles of the reservoir.

Wave-cutting of the reservoir banks has contributed some sediment to the reservoir. An estimate of the amount so added based on field observation and rough measurement, is 4 acre-feet. Approximately 11,000 feet of the shore line shows cut banks over 1 foot high. The average height of the banks is about 3.8 feet, and the average width of the wave-cut terrace is about 10 feet. After several years a resurvey of the bank profiles measured during the present survey should give quantitative information on the importance of wave erosion.

An attempt has been made to calculate the amounts of

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[4]Renner, F. G. Conditions Influencing Erosion on the Boise River Watershed, U. S. Dept. Agr. Tech. Bull. 528, 1936, p. 15.

sediment contributed to the reservoir by each of its two tributaries, particularly because such information would be useful in connection with the work of the Squaw Creek Demonstration Project.

In consideration of the nature and distribution of the reservoir sediments, it is believed that only a very small amount of sediment passes the dam and that therefore the accumulation in the reservoir represents practically the total amount of sediment brought in by the tributary streams. Since the bottom-set beds below the mouth of Squaw Creek consist of sediment from both tributaries, it is not possible to calculate the precise contribution of each stream. However, maximum and minimum figures can be given, assuming first that all of the material in the bottom-set beds came from one tributary, then that all came from the other. On this basis, the contribution of Payette River lies between the limits:

2,657 acre-feet (volume of Payette delta)

3,509 acre-feet (volume of Payette delta plus bottom-set beds) and the contribution of Squaw Creek lies between the limits:

528 acre-feet (volume of Squaw Creek delta)

1,380 acre-feet (volume of Squaw Creek delta plus bottom-set beds). The porosity of the sediments in the different parts of the reservoir varies, depending largely upon the grain sizes. On the basis of studies of the compaction of reservoir sediments carried on at the Soil Conservation Service cooperative laboratory at the California Institute of Technology, Pasadena, Calif.[5] values have been assumed for the porosities of the Black Canyon Reservoir sediments, as follows: Average porosity of the Payette River delta, 55 percent; average porosity of the Squaw Creek delta, 60 percent; average porosity of the bottom-set beds of the reservoir, 65 percent. These figures give weights per cubic foot of 73 pounds, 65 pounds, and 57 pounds, respectively. On this basis, the Payette River delta contains 4,244,471 tons of sediment, the Squaw Creek delta contains 747,489 tons and the bottom-set beds consist of 1,057,724 tons.

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[5]Hough, J. L. Compaction of Sediments with Relation to Silting of Reservoirs, Unpublished manuscript.

The total weight of the material contributed to the reservoir by each of the tributaries lies between the limits given in table 3. These are calculated on the same basis as were the limits of volume (above) i.e., assuming first that all of the material in the bottom-set beds came from one tributary, then that all came from the other.

Table 3.--Sediment contribution of the tributaries of Black Canyon Reservoir

Stream	Total sediment contribution in 12 years	
	Minimum	Maximum
	Tons	Tons
Payette River	4,224,471	5,282,195
Squaw Creek	747,489	1,805,208

The limits given in table 3, particularly for the Squaw Creek contribution, are very wide. The factors involved in the determination of the origin of the bottom-set beds are so complex that no accurate estimate can be made of the amount of material contributed by either stream. Consideration of the large volume of inflow of the Payette River suggests that that stream may have brought in a large part of the sediment in the bottom-set beds. However, several other factors favor Squaw Creek as an important contributor. The more important of these are as follows:

(1) The Squaw Creek delta extends a short distance into the main body of the lake, where the delta front is exposed to current action of the Payette River. The delta, therefore, apparently can extend no farther and sediment reaching the delta front from Squaw Creek is carried farther down and deposited in the bottom-set beds.

(2) Seasonal draw-down of the lake amounting to 14.5 feet causes some part of the delta sediments to be redeposited at lower levels. Much of the material removed from the higher part of the Payette delta probably is redeposited at the front of the delta while the material removed from the upper part of the Squaw Creek delta must be carried into the main body of the lake where it is redistributed by the Payette River current as bottom-set beds.

Although it is impossible to make an accurate estimate of the division of the bottom-set beds as to source, an estimate based on the available evidence may be of some value. As a very rough approximation, it is considered that about half of the bottom-set beds are contributed by each stream. Using this division, the total contribution of each tributary is as follows: The Payette River brought in 4,753,333 tons and Squaw Creek brought in 1,276,351 tons. The average soil loss in the two watersheds, based on these figures, is 0.28 ton per acre per year in the Payette River watershed and 0.47 ton per acre per year in Squaw Creek watershed.

In the Payette watershed the loss appears to represent an amount which would be lost normally under conditions where soil creep on the steep slopes furnishes much of the debris carried by the stream whereas in Squaw Creek watershed, where slopes are commonly less steep, the loss is apparently abnormal, owing to erosion of cultivated and grazing land by surface run-off.

The following tabulation is a statistical summary of data relating to Black Canyon Reservoir, Emmett, Idaho.

	Quantity	Unit
Age:[1]	12	Years.
Watershed:		
Total area	2/ 2,540	Square miles.
Reservoir:		
Original area at crest stage	1,069	Acres.
Present area at crest stage	1,056	Acres.
Original storage capacity	37,659	Acre-feet.
Present storage capacity	33,622	Acre-feet.
Original storage per square mile of drainage area	14.83	Acre-feet.
Present storage per square mile of drainage area	13.24	Acre-feet.
Sedimentation:		
Delta deposits	3,185	Acre-feet.
Bottom-set beds	852	Acre-feet.
Total sediment	4,037	Acre-feet.
Accumulation per year average	336	Acre-feet.
Accumulation per year per 100 square miles drainage area	13.2	Acre-feet.
Accumulation per year per acre of drainage area	9.00	Cubic-feet.
Or, assuming average weight of one cubic foot of silt is 100 pounds.	0.45	Tons.
Depletion of storage:		
Loss of original capacity per year	0.89	Percent.
Loss of original capacity to date of survey	10.72	Percent.

[1]Date storage began: June 1924.
Date of this survey: May 21-August 13, 1936.

[2]Does not include the 210 square miles of drainage area above Payette Lakes (see p. 5 and 6)

Figure 8

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H H BENNETT, Chief W C LOWDERMILK, Associate Chief

BLACK CANYON RESERVOIR
PAYETTE RIVER
GEM COUNTY
IDAHO

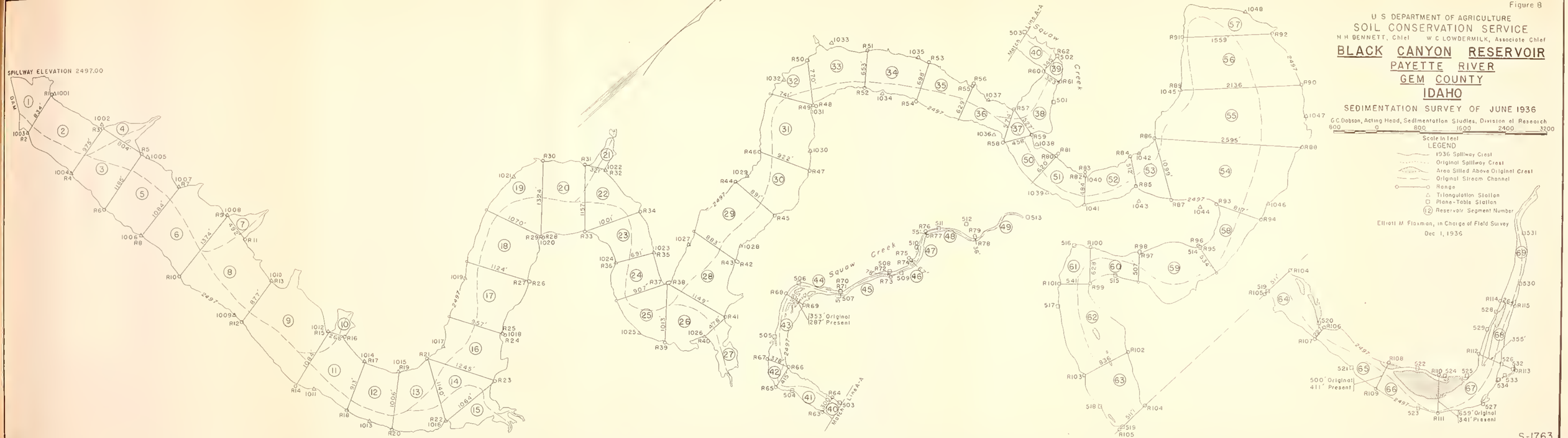
SEDIMENTATION SURVEY OF JUNE 1936

G C Dobson, Acting Head, Sedimentation Studies, Division of Research

800 0 800 1600 2400 3200
Scale in feet

LEGEND
- 1936 Spillway Crest
- Original Spillway Crest
- Area Silted Above Original Crest
- Original Stream Channel
- Range
- △ Triangulation Station
- □ Plane-Table Station
- (12) Reservoir Segment Number

Elliott M Flaxman, in Charge of Field Survey
Dec 1, 1936



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